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FLIGHT EVALUATION ELLIOTT LOW-AIRSPEED SYSTEM

Albert L. Winn, et al

Army Aviation Systems Test Activity

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FLIGHT EVALUATION
ELLIOTT LOW-AIRSPEED SYSTEM

LOW-AIRSPEED SENSOR FINAL REPORT I

ALBERT L. WINN
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US ARMY AVIATION SYSTEMS TEST ACTIVITY
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	ROLE	WT	ROLE	WT	ROLE	WT
Airspeed calibration tests						
Elliott low-airspeed system						
UH-1C helicopter						
Low-speed flight regimes						
Reliable, accurate airspeed data						
Omnidirectional system						
Data on downwash velocity, direction, and performance						
Measurement of induced flow						

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INTRODUCTION

BACKGROUND

1. Standard helicopter airspeed systems use a pitot-static tube to measure flight speed. These systems have a fixed pitot tube which senses the free airstream dynamic pressure in forward flight only. At low airspeeds (low dynamic pressure), the pitot-static pressure fluctuates excessively, causing the system to be inaccurate. Airspeeds below 15 knots are considered unmeasurable.

2. A special airspeed system presently in use for flight testing incorporates a boom-mounted swivel-head probe which allows the pitot tube to swing ±20 degrees from the longitudinal center line, aligning itself with the airflow, thereby reducing errors due to angles of attack and sideslip. However, this arrangement will not provide information for rearward or sideward flight.

3. The US Army Aviation Systems Command (AVSCOM) Test Request No. 71-30 (ref 1, app A) authorizes the US Army Aviation Systems Test Activity (USAASTA) to conduct theoretical or conceptual flight evaluations of low-airspeed systems. An ideal low-airspeed system should be able to measure airspeed omnidirectionally from zero to 250 knots.

4. Elliott Flight Automation Ltd. designed and built a low-airspeed system capable of measuring airspeeds of 30 knots, rearward, to 200 knots, forward. The system was designed to measure the rotor downwash magnitude and skew angle, and resolve them to a horizontal airspeed. When the sensor transitions out of the rotor wake, the system is indicating free stream velocity. Since at low airspeeds the system operates in the rotor wake, the dynamic pressure never drops below the threshold for a pitot-static system. Flight in any translational direction can be measured by rotating the sensor to align the probe into the direction of flight.

5. The airspeed system tested is a laboratory unit in the developmental stage. The equipment was provided on consignment at no cost to the government.

TEST OBJECTIVES

6. The overall objective was to determine the feasibility of the Elliott system for use as a helicopter airspeed instrument. Specific objectives included:

   a. Effects of ground proximity on the sensor performance.

   b. Variation in sensor performance with proximity of fuselage or other aerodynamic obstructions.

c. Comparison of sensor performance in forward, rearward, and sideward flight.

d. Gathering data for further development of an omnidirectional airspeed system.

DESCRIPTION

7. The Elliott helicopter low-airspeed sensing and indicating equipment (LASSIE) is manufactured by Elliott Flight Automation Ltd., Airport Works, Rochester, Kent, England.

8. The system is based on the principle that the resultant downwash angle (γ) and velocity ($\bar{V}$), is a function of the flight-path airspeed (V), and the rotor induced flow magnitude (v) and angle (i). The resultant airflow resolved into the horizontal plane is derived from the equation shown below and is presented graphically in figure A.

$$\bar{V} \cos \gamma = V + v \sin i$$

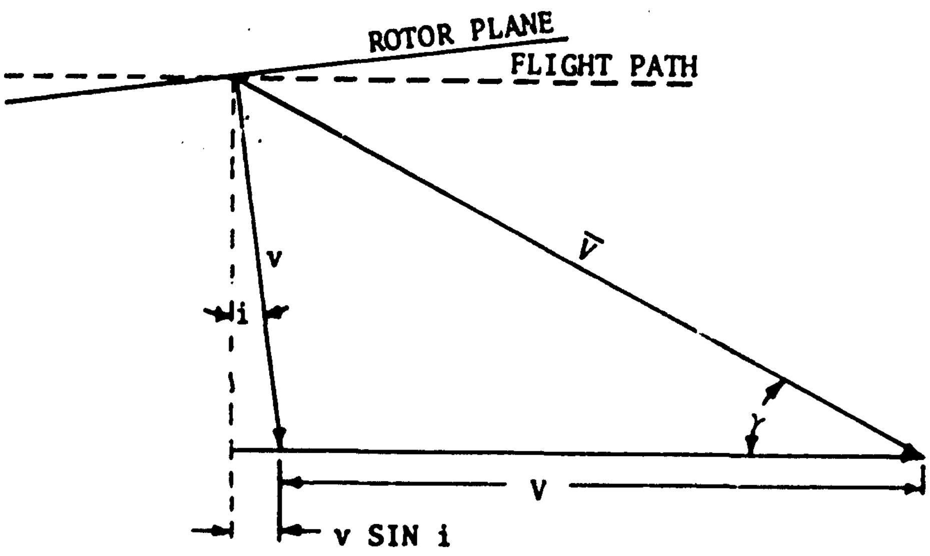
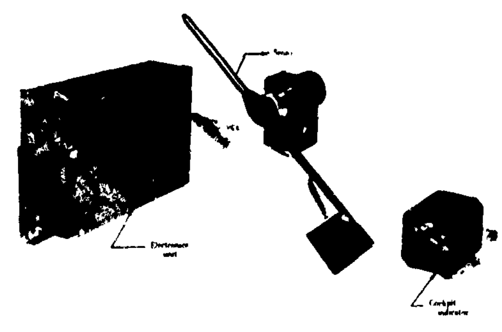


Figure A. Rotor Downwash Vector Representation.

Since at low speed (i) is small and at high speed (v) is small, the equation can be simplified and horizontal airspeed can be obtained from $V = \bar{V} \cos \gamma$.

9. The sensor consists of a swiveling pitot-static probe with a guide vane which is capable of measuring the magnitude ($\overline{V}$) and angle (γ). The vane aligns the pitot probe with the airstream in one plane only; therefore, airspeed is resolved to a single axis.

10. The system includes an airspeed computer unit, airspeed indicator, and sensor, as shown in photograph A. A detailed description is contained in reference 2, appendix A.



Photograph A. Elliott Low-Airspeed System.

11. The swiveling pitot-static probe, type 05-004-01, consists of a standard pitot-static sensing head with four peripheral circular static vents. The wedge-shaped vane is ballasted to statically balance the probe about the swivel point. A synchro resolver in the swivel measures probe position. The total and static air pressures are piped into the central computer along with the probe angle signal from the synchro resolver.

12. The airspeed computer unit is a solid-state design and requires a 115-volt, 400-hertz (Hz) power source. The unit resolves the pitot-static pressure and servo angle information into a signal which is displayed on the cockpit indicator. Provision can also be made to record the signal with an oscillograph or tape instrumentation system.

13. The airspeed indicator consists of a servomotor and tachometer-generator and a feedback potentiometer. This provides an indicator rate signal and position signal

which is fed back to the computer, and summed with the computed horizontal speed. The summed signal is checked by a servo monitor, and detected failures are indicated by a warning flag on the indicator.

14. The test aircraft was a UH-1C helicopter, S/N 63-8684, manufactured by the Bell Helicopter Company. A detailed description is contained in the operator's manual (ref 3, app A).

SCOPE OF TEST

15. The Elliott low-airspeed system was tested at Edwards Air Force Base, California, by USAASTA between 21 June and 15 November 1971. The evaluation consisted of 13.7 test flight hours.

16. Flight conditions were held within the limitations contained in the operator's manual (ref 3, app A). All flights were at a mid center of gravity and an engine start gross weight of approximately 7000 pounds.

17. Tests were flown in longitudinal and lateral flight, in ground effect and out of ground effect, and under static and dynamic conditions.

METHOD OF TEST

18. The Elliott airspeed system was tested at low speeds (zero to 50 knots) near the ground, using a pace-car calibration technique. A calibrated fifth wheel attached to the pace car was used to measure ground speed. Reference airspeed was obtained by adjusting the ground speed data by the wind readings measured at ground level along the flight path. Tests were conducted in winds less than 5 knots.

19. High-speed data (50 to 120 knots indicated airspeed (KIAS)) were referenced to the calibrated swivel-head boom system. Sideslip angles were measured with a boom-mounted sideslip vane, and rate of climb was derived from the aircraft altimeter.

CHRONOLOGY

20. The chronology of testing is as follows:

Test equipment received	21	June	1971
Test equipment installed	22	June	1971
Flight tests begun	29	June	1971
Flight tests completed	15	November	1971

RESULTS AND DISCUSSION

GENERAL

21. An airspeed sensor mounted on a helicopter must contend with unique airflow and operating characteristics. The ability of the helicopter to move in any direction requires a similar degree of freedom in the sensor. The combination of high-speed rotor downwash and low-speed inflow from the direction of flight has prevented satisfactory use of a standard pitot-static sensor. However, the Elliott sensor uses the downwash velocity to ensure that the sensor will have sufficient dynamic pressure to accurately position the vane and provide airspeed information. In addition, the low-speed horizontal component is not a difficulty because it is not actually sensed. Flight in a given direction can only be accomplished by deflecting the rotor downwash. The deflection angle is combined with the downwash velocity to provide the magnitude of the horizontal component. The system was based on momentum theory which assumes the rotor as a disc and the rotor wake as a uniform slipstream. For a real operating rotor, there are variations in the downwash characteristics which deviate from the ideal condition.

22. Since the airspeed is derived from rotor downwash velocity and deflection angle, each system is designed for a particular location on a given type helicopter and will be inaccurate for any other application. However, the system can be calibrated, and with the position error data, accurate information can be obtained. Thus, it is to be expected that each sensor location tested will yield different results.

23. Within the accuracy of the airspeed standards available, the Elliott low-airspeed system can indicate airspeed measurement down to zero knots. The airspeed information provided by the system is essentially linear. However, the calibration curves show a discontinuity at the airspeed at which the sensor encounters the edge of the rotor slipstream. Sideslip angle, climbing and descending flight, and ground proximity can introduce errors which detract from the system performance.

AIRSPEED SYSTEM CALIBRATION

24. The Elliott low-airspeed system was designed to have a range of 30 knots, rearward, to 200 knots, forward, when aligned with the longitudinal axis of the aircraft. The sensor was intended to operate in the rotor wake, and when it transitions out of this area, there is a drop in the airspeed reading and a corresponding change in the slope of the calibration curve. Once the sensor is in the free stream, the probe angle is approximately zero, and the system therefore is essentially indicating the free stream velocity.

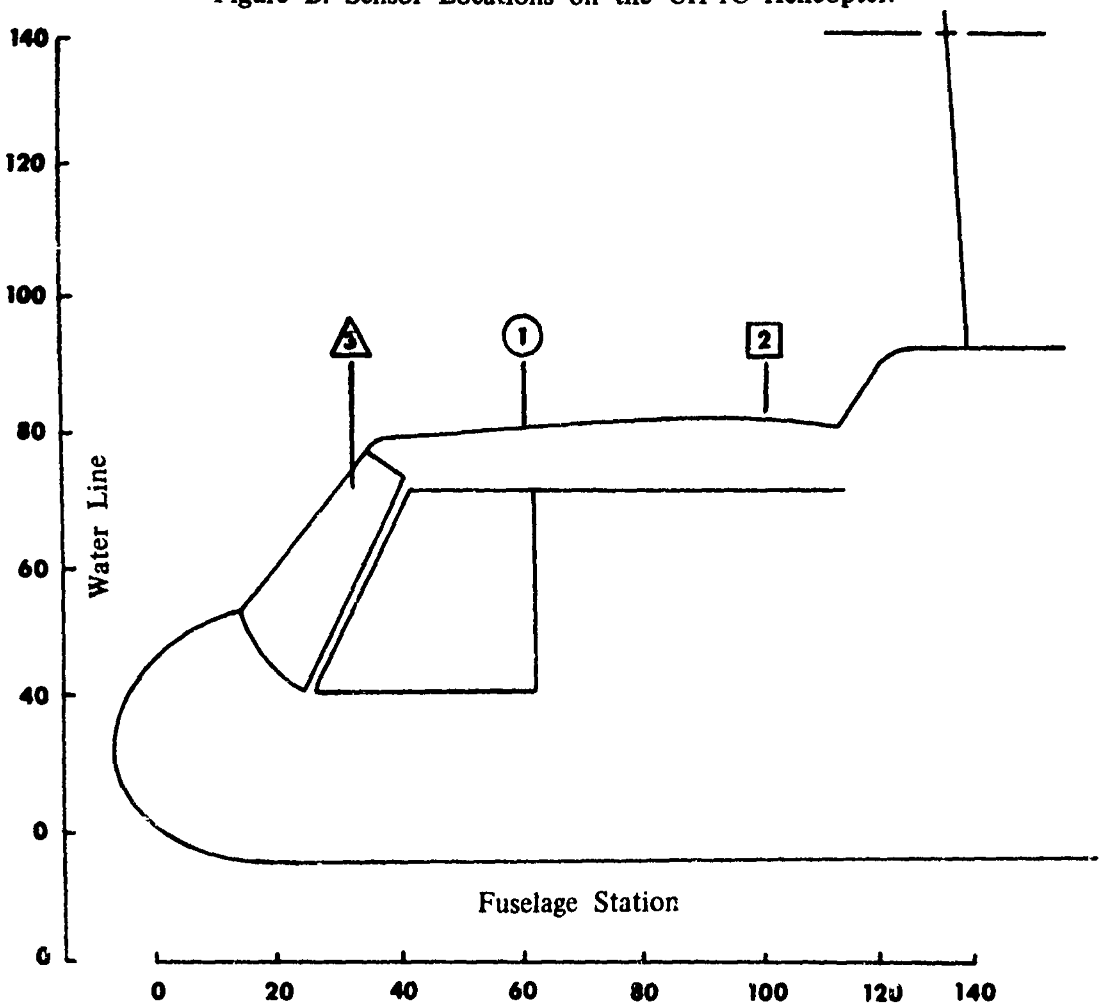
25. The location with respect to the rotor plane influences the downwash velocity which the sensor will experience. Also, for a given longitudinal or lateral displacement, this distance will determine at what airspeed the sensor will pass out of the rotor wake. During the calibration tests, the sensor was evaluated for the positions shown in figure B. For these locations, the downwash is not the same with respect to velocity or direction. In addition, the system was not designed for the UH-1C, so there was a position error for each of the locations tested.

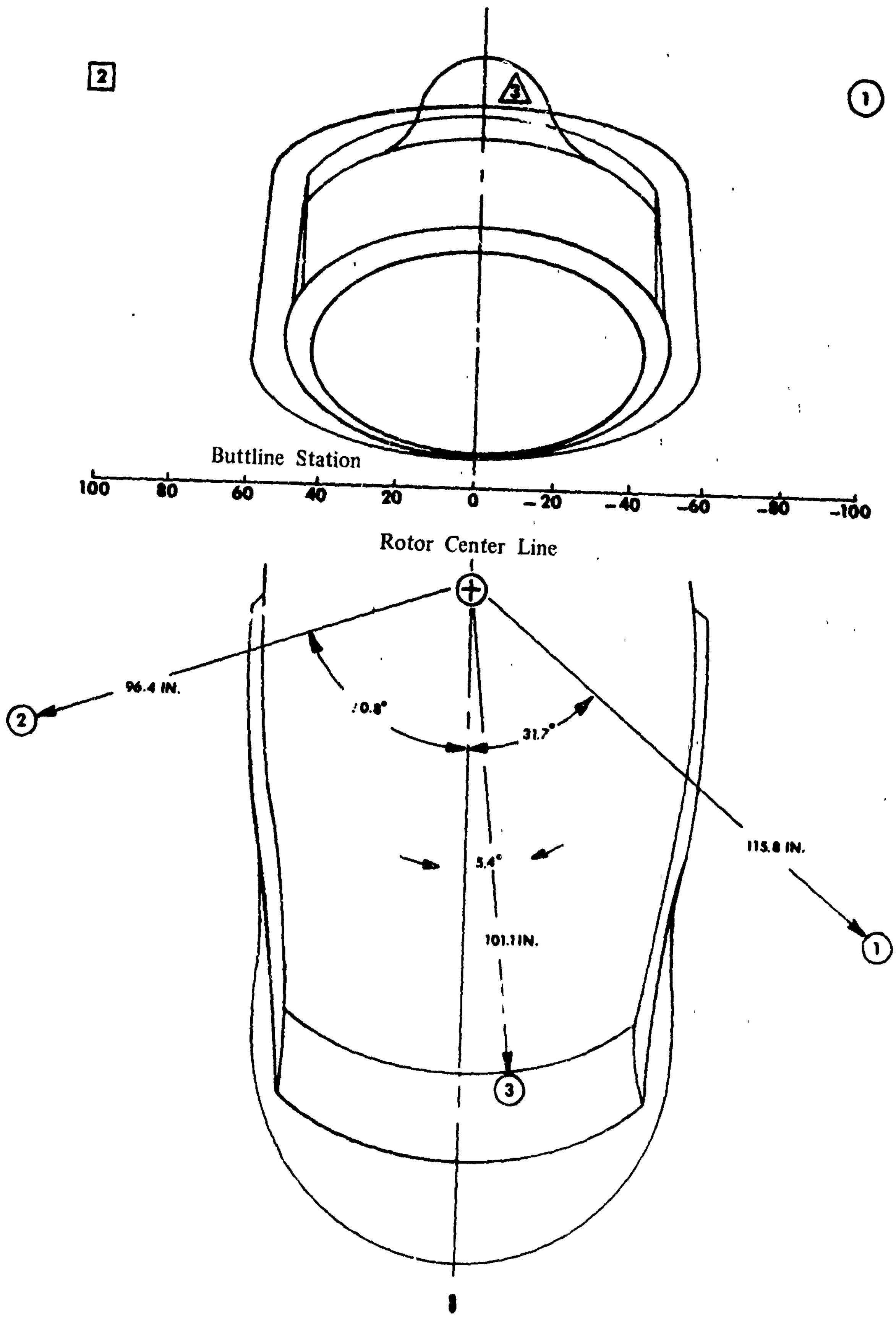
Left-Side Position

26. The left-side position is shown in photograph 1, appendix B. The sensor was at fuselage station (FS) 55.5, buttline (BL) -87.6, and water line (WL) 86.5. The calibration in forward and rearward flight for this position is shown in figure 1, appendix C. From a rearward speed of 25 knots calibrated airspeed (KCAS) to a forward speed of 13 KCAS, the calibration is essentially linear. At 13 KCAS, the sensor transitions from the rotor downwash to a free stream environment. At this point, there is a sharp discontinuity in the airspeed calibration and a position error decrease of 14 knots. Beyond 17 KCAS, the calibration is again linear, although the slope is different. At an airspeed of 20 KCAS, the error is only 2 knots and increases to 30 knots at 110 KCAS. This large position error may have been caused by the probe design or proximity of the probe to the fuselage. It was repeatable for the conditions tested and, therefore, could be corrected electronically. The sensor probe angle is relative to the aircraft longitudinal axis. The flight path angle relative to the fuselage changes with airspeed, flight condition, and aircraft loading. This position error may change with flight conditions or loading at conditions not tested. Aircraft pitch attitude may be a necessary input to make the position error repeatable for all flight conditions and loads. A typical pitch attitude and airspeed relationship for the UH-1C helicopter in forward flight (ref 5, app 1) is shown in figure C.

27. The vane angle and airspeed relationships are shown in figure 2, appendix C. The sensor was aligned with the longitudinal axis of the aircraft which corresponds to a vane angle of zero. The vane deflection was essentially linear with airspeeds from 25 KCAS, rearward, to 25 KCAS, forward, and shows the wake angle variation with airspeed. The transition to free stream is evident. While under the rotor wash, the downwash speed increases with airspeed in either direction. As the sensor transitions to free stream air at 13 to 17 KCAS, there is a sharp discontinuity in the measured airspeed.

Figure B. Sensor Locations on the UH-1C Helicopter.





2
3
1
Buttline Station
100
80
60
40
20
0
-20
-40
-60
-80
-100
Rotor Center Line
96.4 IN.
2
31.7°
5.4°
115.8 IN.
1
101.1 IN.
3

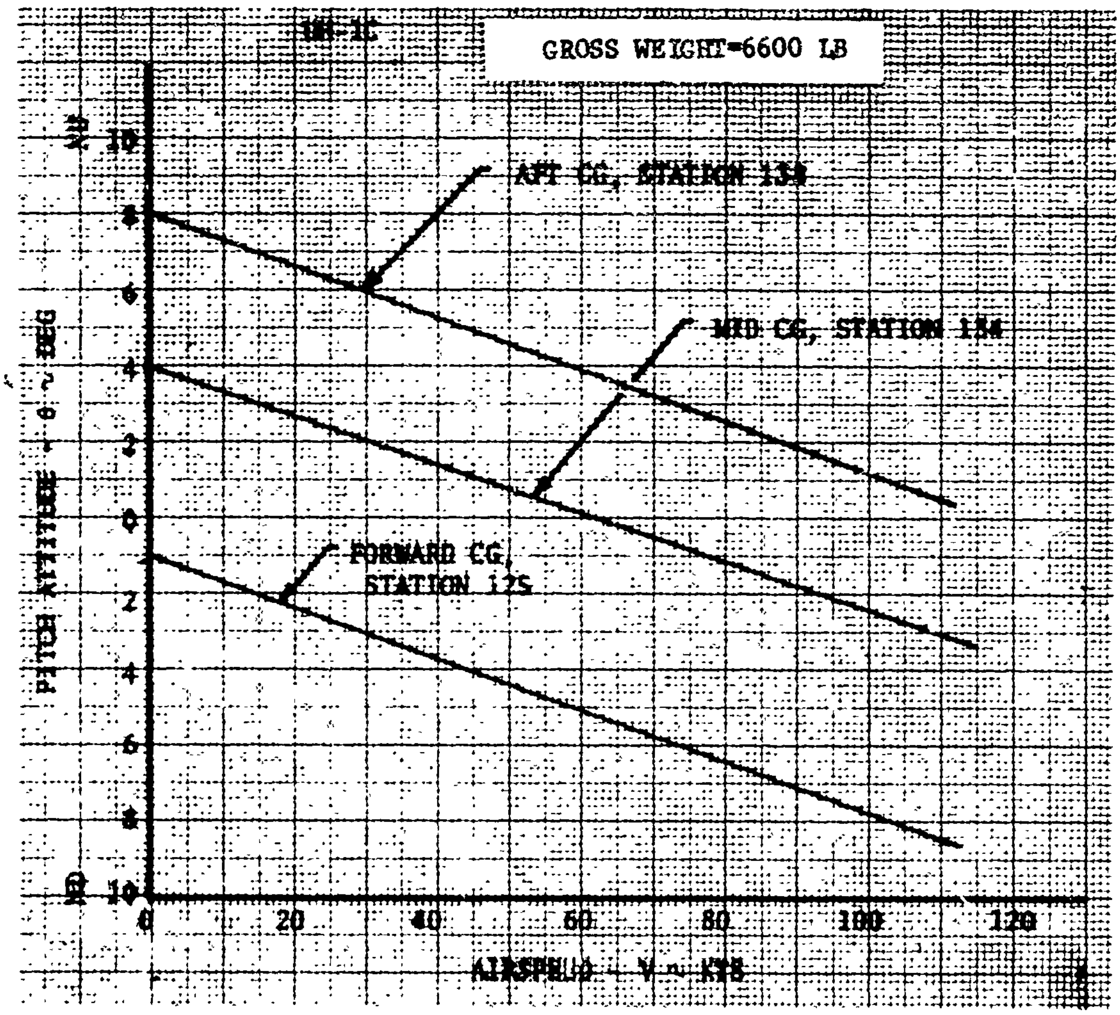


Figure C. Pitch Attitude Characteristics in Forward Flight.

Right-Side Position

28. The sensor installation for the right-side position was at FS 99.5, BL 91, WL 88, and is shown in photograph 2, appendix B. Test data for this location are shown in figures 3 and 4, appendix C. A comparison of the calibrations for the left and right positions is shown in figure D. Since the sensor and computer operation is fixed for both locations, the comparison shows the variation in the airflow characteristics. The slopes are essentially the same, although the transition point is shifted.

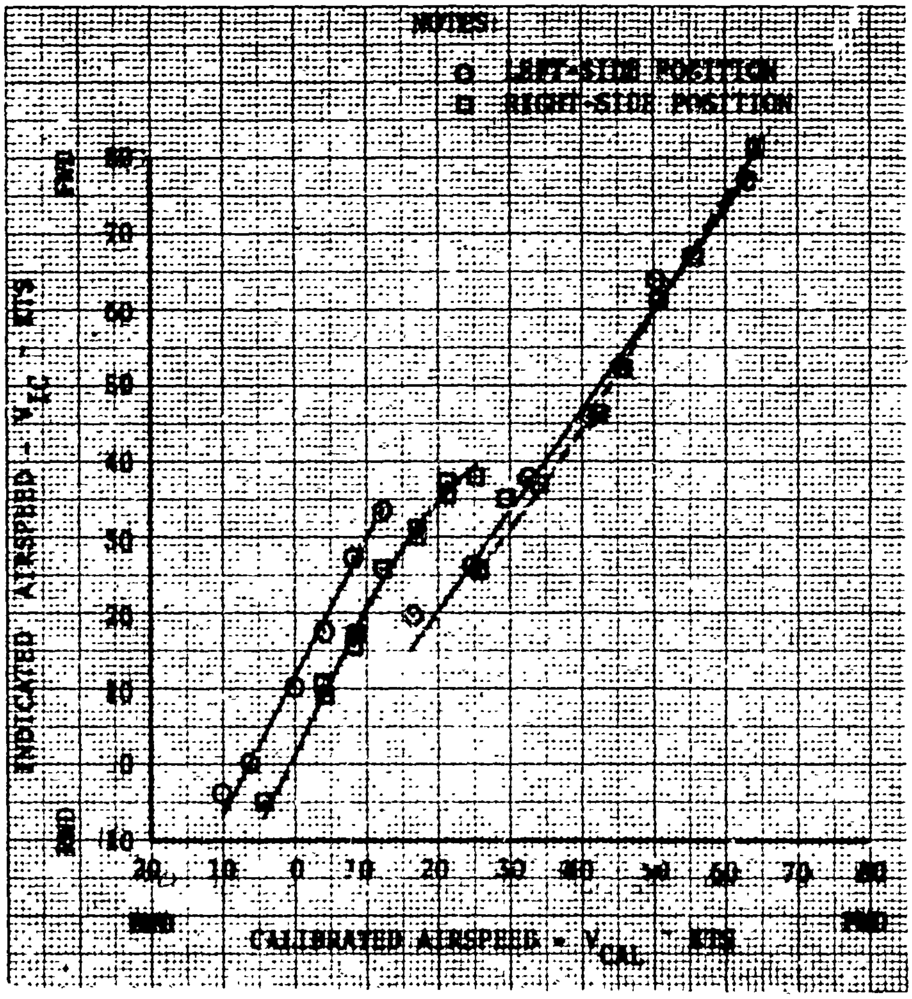


Figure D. Comparison of Airspeed Calibrations for Left- and Right-Side Positions.

29. The vane angle and indicated airflow characteristics reflect the airspeed calibration results (fig. 4, app C). The most noticeable difference from the left-side position is that the vane angle is at 10 degrees for all speeds above the transition point. During the installation, the sensor position relative to the aircraft center line was not precisely defined, which could possibly account for the angle difference.

30. In the right-side position, the sensor was also oriented with the sensitive axis 90 degrees to the aircraft longitudinal axis to provide airspeed information during sideward flight. In this configuration, the vane could pivot laterally in the direction of airflow. Test results are shown in figures 5 and 6, appendix C. As shown in figure 5, the indicated airspeed is slightly nonlinear. However, it is symmetrical

about zero. Anomalies occurring in left sideward flight were attributed to turbulence from the rotor mast or fuselage. For left sideward flight, the sensor remains under the rotor wake for a speed of at least 25 KCAS, which was the limit of the test equipment.

31. Comparison of figure 5 with figure 3, appendix C, shows the effects of azimuth heading on indicated airspeed. The slope of the calibration curve is less in sideward flight than in forward/rearward flight. The difference in calibrations is mostly attributed to the indicated downwash angle relation with airspeed. Figures 4 and 6 show the indicated downwash angle with airspeed for the two headings. The slope of the curve in sideward flight is less than in forward/rearward flight, which is consistent with the indicated airspeed calibration. The distance from the probe to the vertical plane through the rotor mast, perpendicular to the flight path, is less, which would account for the variation in indicated downwash angle.

Center Position

32. In the center position, the sensor was installed as shown in photograph 3, appendix B. The sensor position is defined by FS 30.5, BL -9.5, and WL 86. The sensor alignment was with the helicopter lateral axis to allow measurement of sideward airspeed. Test results in figures 7 and 8, appendix C, show that at a hover the vane angle is deflected 30 degrees to the right from the vertical. The variation of vane angle with lateral airspeed is particularly high and distorted, suggesting that the airflow is affected by the proximity of the fuselage. Both the vane angle and downwash airspeed data show the sensor to be under the rotor wake from 25 KCAS, left sideward flight, to 15 KCAS, right sideward flight. With the exception of the bias near hover which shifts the curve, the airspeed calibration is nearly symmetrical. At this location, the distance from the probe to the vertical plane through the rotor mast, perpendicular to the flight path, is greater than the other positions. Also, the slope of the calibration curve is greater than either of the forward/rearward calibrations. This indicates, in conjunction with the results stated in paragraph 31, that a similar calibration slope to the forward/rearward calibration can be achieved by positioning the probe equidistant longitudinally and laterally from the rotor mast.

SIDESLIP CHARACTERISTICS

33. The Elliott airspeed system is not omnidirectional. The sensor probe pivots about a single axis, allowing measurement in a single plane. A conventional sideslip condition introduces an airspeed component at an angle to the rotational plane of the vane. This will alter the dynamic and static pressure fields around the probe and cause the calibration to change. The vane is restrained in the plane of rotation and is not sensing the resultant airflow and attitude angle.

34. Results for tests conducted in forward level flight at 63 KCAS are shown in figure 9, appendix C. The probe is in free stream airflow at this flight condition, which allowed comparison with the boom-mounted sideslip vane. Sideslip in either

direction introduced a decrease in indicated airspeed which became larger with greater sideslip. The characteristics were similar to those measured for fixed pitot-static probes in USAASTA Project No. 68-12 final study (ref 4, app A).

35. The sideslip data show the characteristics of the probe in a misaligned airflow. An approximate error in low-speed flight can be calculated by determining the downwash vector from figures 2 and 4, appendix C, and then applying the sideslip influence shown in figure 9.

GROUND PROXIMITY EFFECTS

36. Ground proximity can affect the system performance in several ways. As the aircraft approaches ground level, the rotor induced velocity required is decreased. Downwash reflecting from the ground can introduce turbulence which will cause airspeed and vane angle variation and fluctuation.

37. The test results are presented in figure 10, appendix C. At the 10-foot skid height, the downwash velocity is less than at the 50-foot skid height and the sensor angle is more vertical. The influence of the ground effect diminishes with forward speed and appears to be nonexistent at airspeeds above 20 KCAS. Although not investigated in detail in this evaluation, qualitative data indicate that ground effect is most significant at heights below 25 feet and becomes less significant as height is increased above 25 feet. At the 10-foot height, airspeed oscillations of ±5 knots were observed on the cockpit indicator.

INFLUENCE OF CLIMB AND DESCENT

38. The sensor responds to total downwash, which is the result of combined induced flow and horizontal inflow. Thus, for a given gross weight and level flight condition, there is a unique downwash airspeed and angle. A change in thrust caused by a change in gross weight or climb and descent will change the induced flow and the indicated airspeed. Likewise, at a constant airspeed, a change in attitude caused by a change in flight regime will change the downwash angle and the indicated airspeed value.

39. The results of a vertical climb initiated from a hover are shown in figure 11, appendix C. The collective application rapidly increases the downwash speed. This is evident in the sharp rise in indicated airspeed immediately following the input. The induced flow is interpreted by the system computer as an airspeed increase and is so displayed by the indicator. A reverse situation would occur during a descent.

40. The induced velocity in a hover can be used as a measure of total thrust and power required. Hovering at different gross weights would then calibrate the

system, and, knowing power available, an excess thrust margin could be predicted. This excess thrust margin could be converted to helicopter performance capability in terms of hovering, takeoff, or climb performance.

INSTALLATION, OPERATION, AND RELIABILITY

41. The experimental system provided for this evaluation is not representative in size, construction, or weight of that expected in production systems. However, during the evaluation, the system was installed several times in different locations with relative ease and a minimum of technical skills required. The experimental system included a recording device which would not be present for a production system. A typical installation, as shown in appendix B, required approximately 4 hours to accomplish.

42. Figure 12, appendix C, presents a representative operation of the system. The indicated airspeed was stable. The instrument was not damped and provided a free response to perturbations. The downwash data reveal a small oscillation of approximately 12 cycles per second caused by the passage of each blade over the sensor. This, however, was smoothed and was not noticeable on the cockpit visual indicator. As previously discussed, operation near the ground introduces airspeed and vane oscillations which tend to degrade the performance.

43. With all the various installations and usage made of the equipment, there was no failure during the course of the program, with the exception of the recording device. The system is relatively simple and demonstrated a high degree of reliability.

CONCLUSIONS

44. The Elliott low-airspeed system can provide reliable, accurate airspeed information in level flight from hover to 120 knots in a given direction (paras 26, 28, 31, 32, and 42).

45. The system operates well in rotor downwash or in free stream air; however, there is a discontinuity in the airspeed calibration curve at the point where the sensor transitions through the edge of the rotor downwash (para 26).

46. Sideslip introduces errors similar to those encountered for fixed pitot-static probes (para 34).

47. Ground proximity introduces downwash airspeed and downwash angle fluctuations which are sensed by the Elliott system (para 37).

48. The sensor can provide information concerning the magnitude of the rotor downwash and downwash angle which can be used to measure aircraft performance (para 40).

49. The system is relatively simple and is highly reliable (para 43).

RECOMMENDATIONS

50. Further studies should be conducted toward the development of an operational omnidirectional airspeed system.

51. The system should be used as a flight test instrument to provide reliable airspeed and downwash information.

52. Additional testing should be conducted to evaluate the feasibility of using the system as a helicopter performance measurement device.

APPENDIX A. REFERENCES

1. Letter, AVSCOM, AMSAV-EF, 20 July 1971, subject: Flight Test of Low Airspeed Sensors.

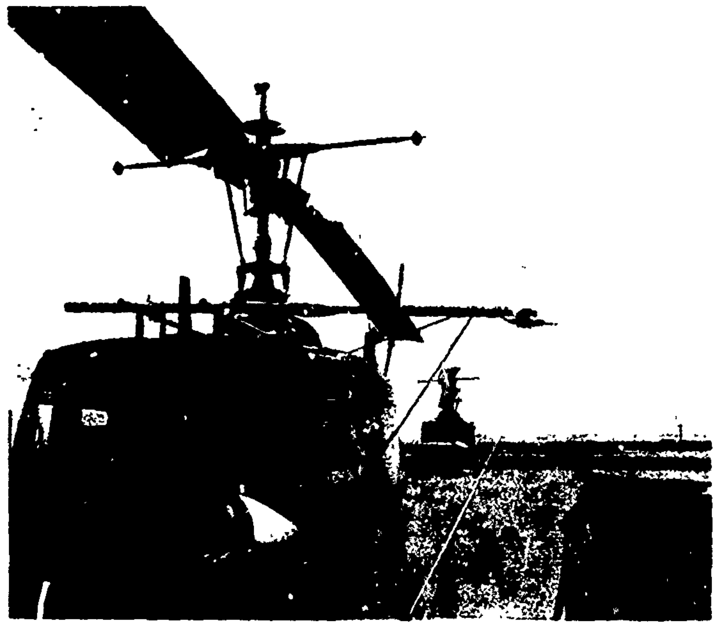
2. Report, Elliott Flight Automation Ltd., 260/434/5/D04, *Brief Notes on the Flight Test of the Elliott Helicopter Low Airspeed Sensing and Indicating Equipment*, April 1971.

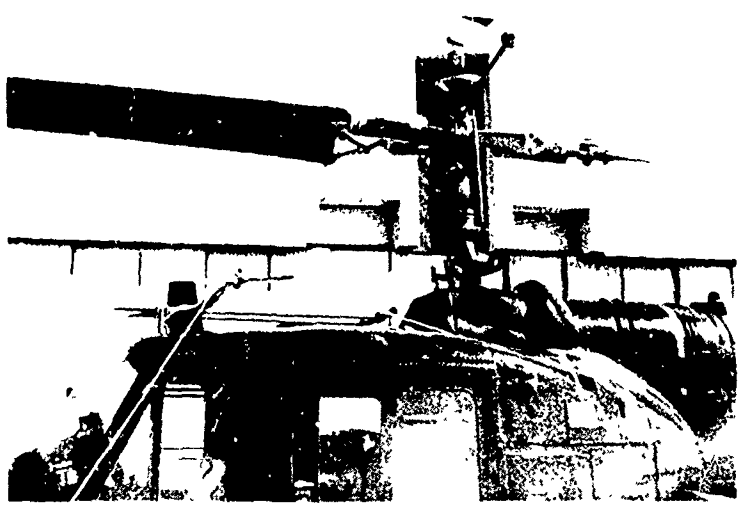
3. Technical Manual, TM 55-1520-220-10, *Operator's Manual, Model UH-1C Helicopter*, November 1968, with Change 1, September 1969.

4. Final Study, USAASTA, Project No. 68-12, *Wind Tunnel and Flight Evaluation, Rosemount Shielded Pitot-Static Tube Model 850N*, April 1970.

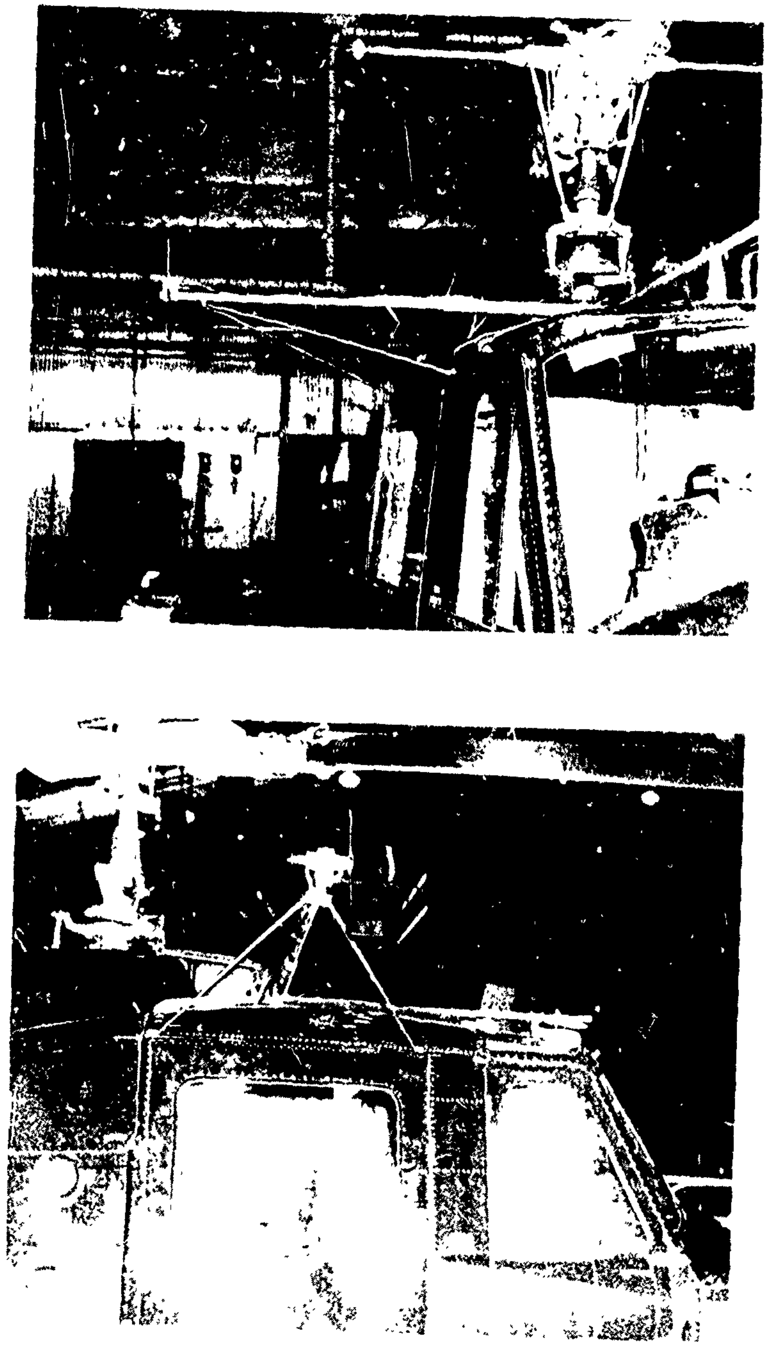
5. Report, Aeroflex Laboratories Inc., 0942-R-020, *Final Engineering Report, True Airspeed Vector System*, July 1971.

APPENDIX B. PHOTOGRAPHS

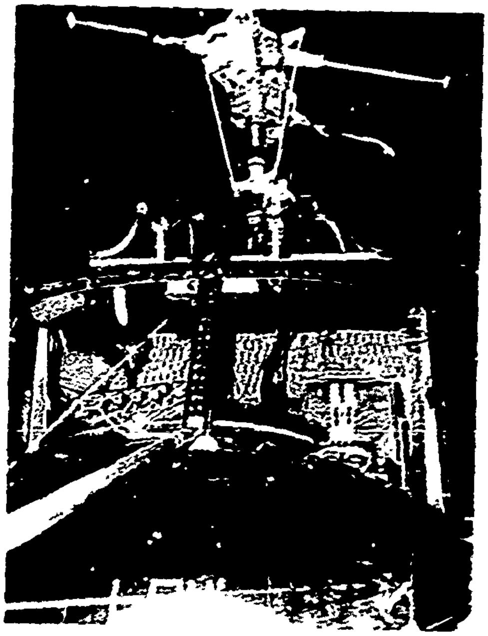


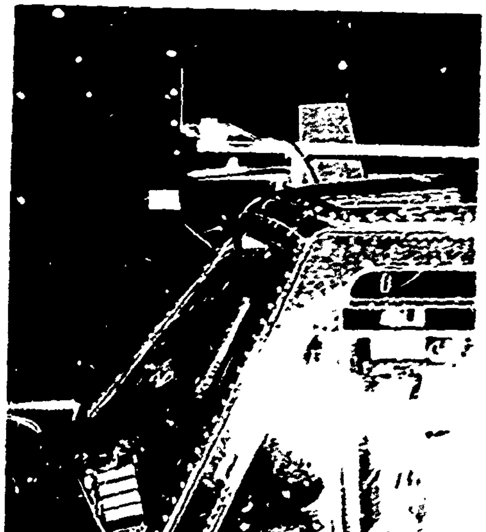


Photograph 1. Front and Side Views of Elliott Low-Airspeed Sensor Left-Side Position.



Photograph 2. Front and Side Views of Elliott Low-Airspeed Sensor Right-Side Position.





Photograph 3. Front and Side Views of Elliott Low-Airspeed Sensor Center Position.

APPENDIX C. TEST DATA

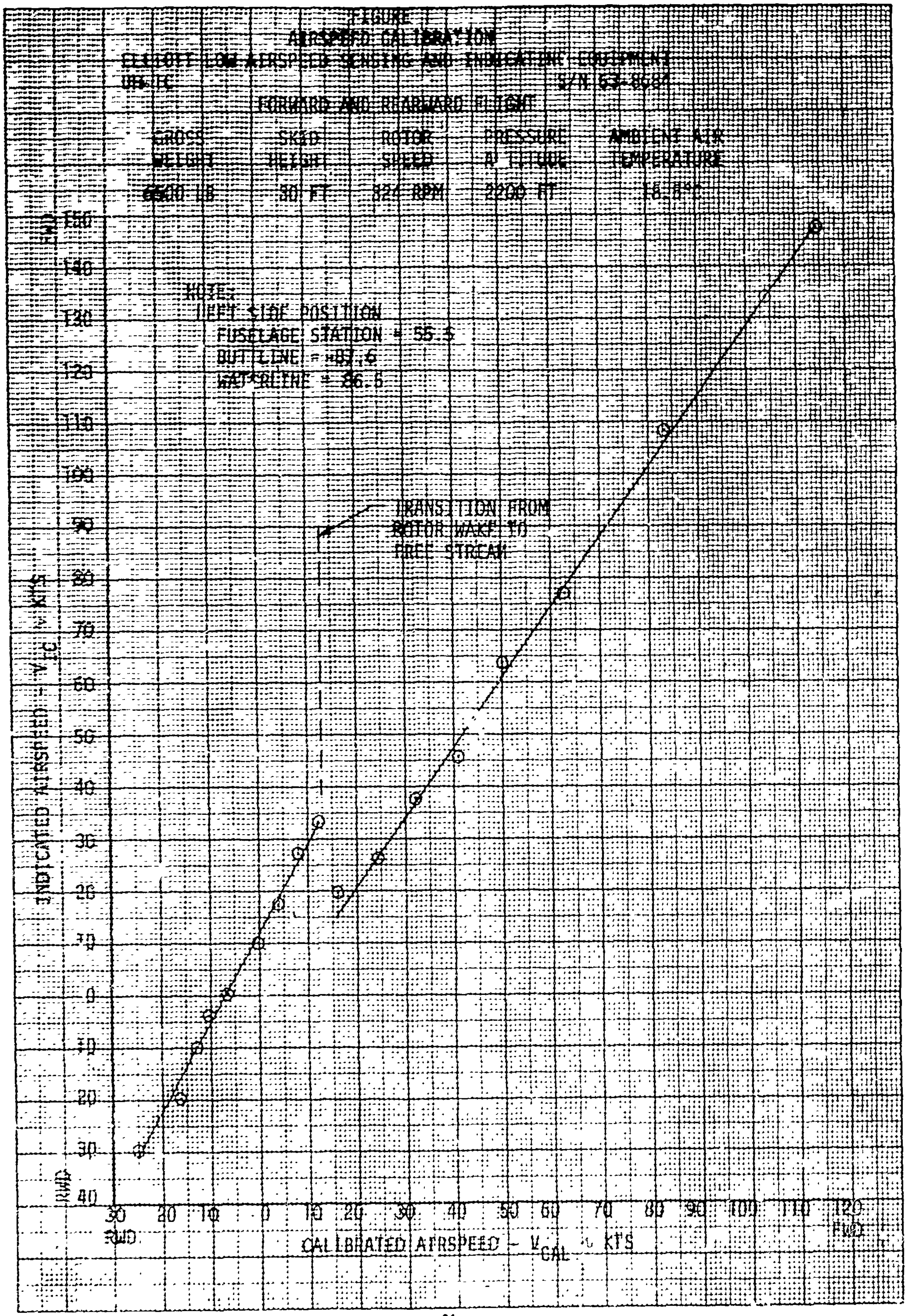


FIGURE
AIRSPEED CALIBRATION
ELLIOTT LOW AIRSPEED SENSING AND INDICATING EQUIPMENT
UH-1C
S/N 63-8684
FORWARD AND REARWARD FLIGHT
GROSS WEIGHT
SKID HEIGHT
ROTOR SPEED
PRESSURE ALTITUDE
AMBIENT AIR TEMPERATURE
6600 LB
30 FT
324 RPM
2200 FT
NOTES:
LEFT SIDE POSITION
FUSELAGE STATION = 55.5
BUTTLINE = -37.6
WATERLINE = 86.5
TRANSITION FROM ROTOR WAKE TO FREE STREAM
INDICATED AIRSPEED - V_{IC} ~ KTS
FWD
RWD
CALIBRATED AIRSPEED - V_{CAL} ~ KTS
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
10
20
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30
20
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80
90
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110
120

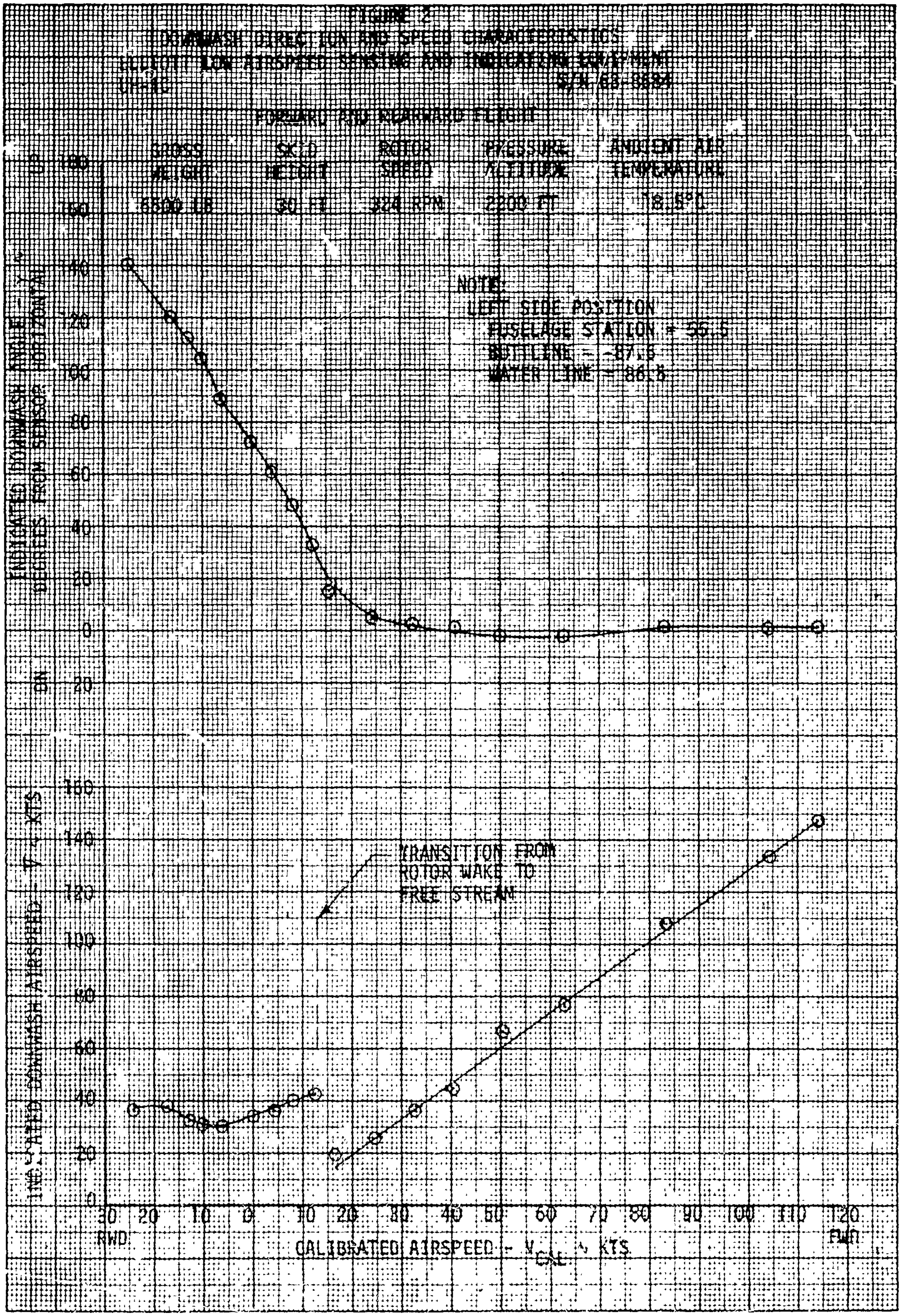
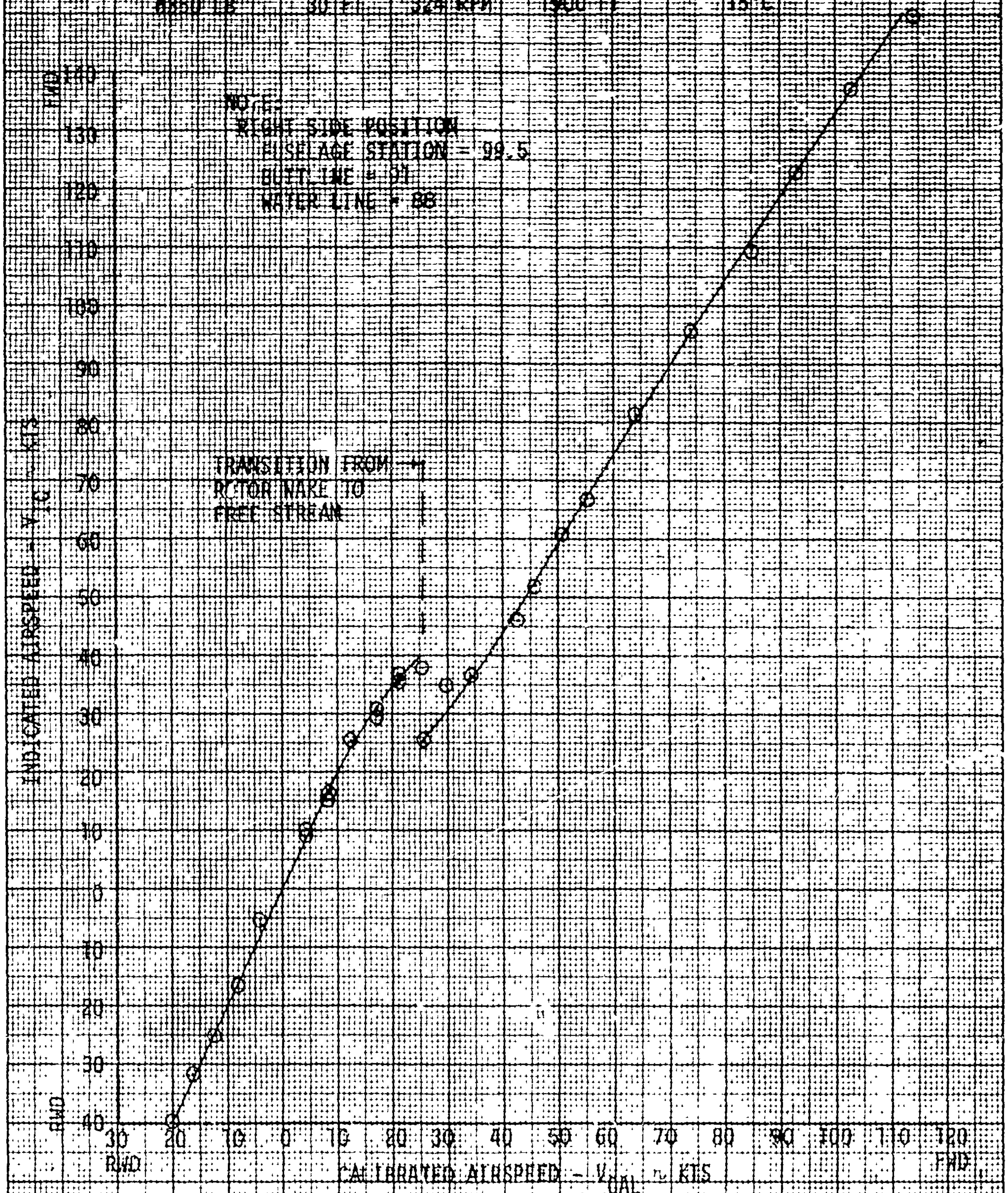


FIGURE 2
DOWNWASH DIRECTION AND SPEED CHARACTERISTICS
LOW AIRSPEED SENSING AND INDICATING EQUIPMENT
FORWARD AND REARWARD FLIGHT
GROSS WEIGHT
SKID HEIGHT
ROTOR SPEED
PRESSURE ALTITUDE
AMBIENT AIR TEMPERATURE
6600 LB
30 FT
324 RPM
2200 FT
18.5°C
NOTE:
LEFT SIDE POSITION
FUSELAGE STATION = 56.5
BUTTLINE = -87.5
WATER LINE = 86.5
INDICATED DOWNWASH ANGLE
DEGREES FROM SENSOR HORIZONTAL
UP
DN
TRANSITION FROM ROTOR WAKE TO FREE STREAM
INDICATED DOWNWASH AIRSPEED - KTS
RWD
FWD
CALIBRATED AIRSPEED - V_{CAL} - KTS

FIGURE 3
AIRSPEED CALIBRATION
ECLOT: LOW AIRSPEED SENSING AND INDICATING EQUIPMENT
UH-1C S/N 63-8684

FORWARD AND REARWARD FLIGHT

GROSS WEIGHT	SKID HEIGHT	ROTOR SPEED	PRESSURE ALTITUDE	AMBIENT AIR TEMPERATURE
6850 LB	30 FT	324 RPM	1900 FT	15°C



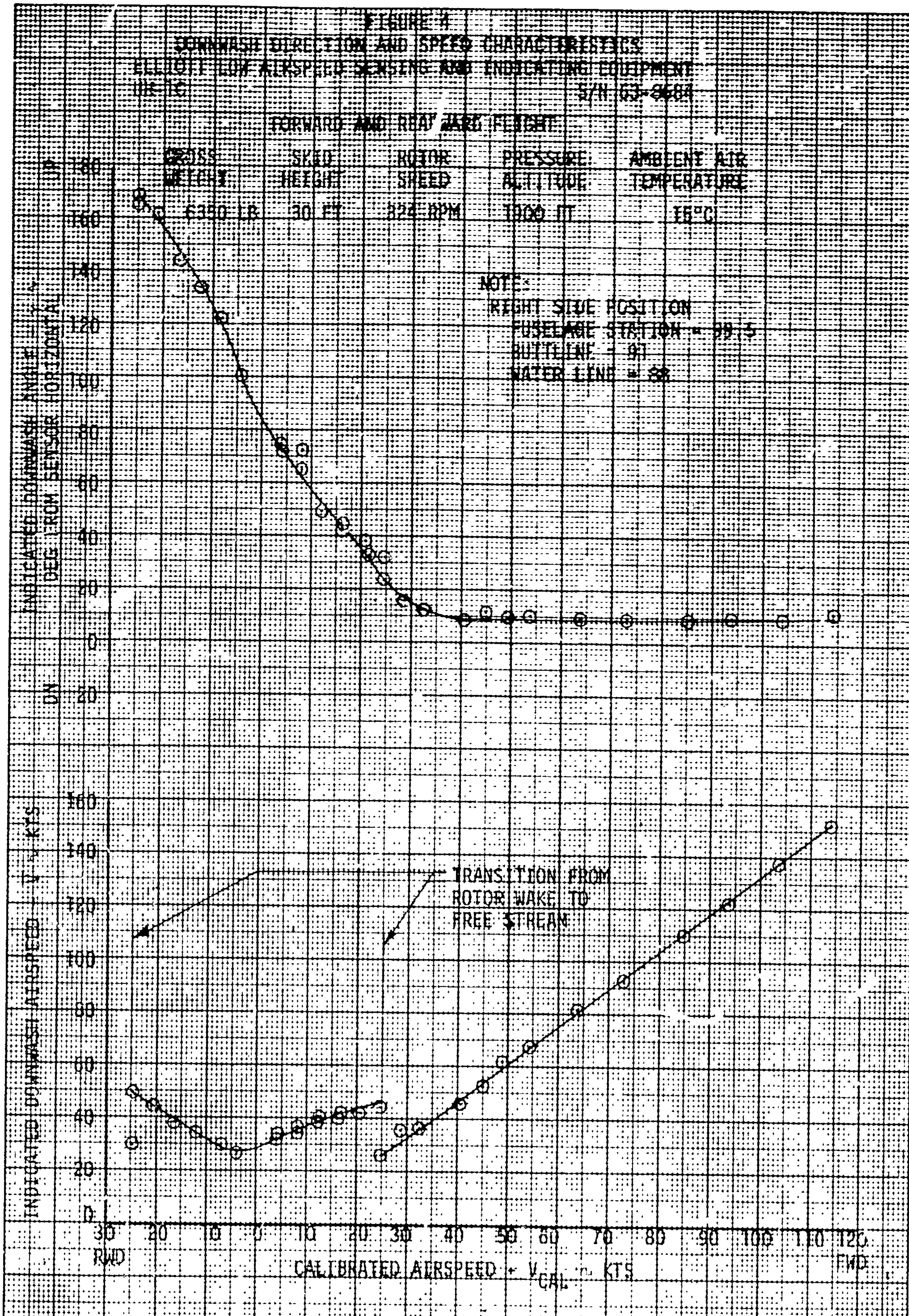


FIGURE 4
DOWNWASH DIRECTION AND SPEED CHARACTERISTICS
ELLIOTT LOW AIRSPEED SENSING AND INDICATING EQUIPMENT
UH-1C
FORWARD AND REARWARD FLIGHT
GROSS WEIGHT
SKID HEIGHT
ROTOR SPEED
PRESSURE ALTITUDE
AMBIENT AIR TEMPERATURE
6350 LB
30 FT
324 RPM
1000 FT
15°C
NOTE:
RIGHT SIDE POSITION
FUSELAGE STATION
BUTTLINE
WATER LINE
UP
DN
INDICATED DOWNWASH ANGLE
DEG FROM SENSOR HORIZONTAL
TRANSITION FROM ROTOR WAKE TO FREE STREAM
INDICATED DOWNWASH AIRSPEED ~ KTS
RWD
FWD
CALIBRATED AIRSPEED ~ V_{CAL} ~ KTS

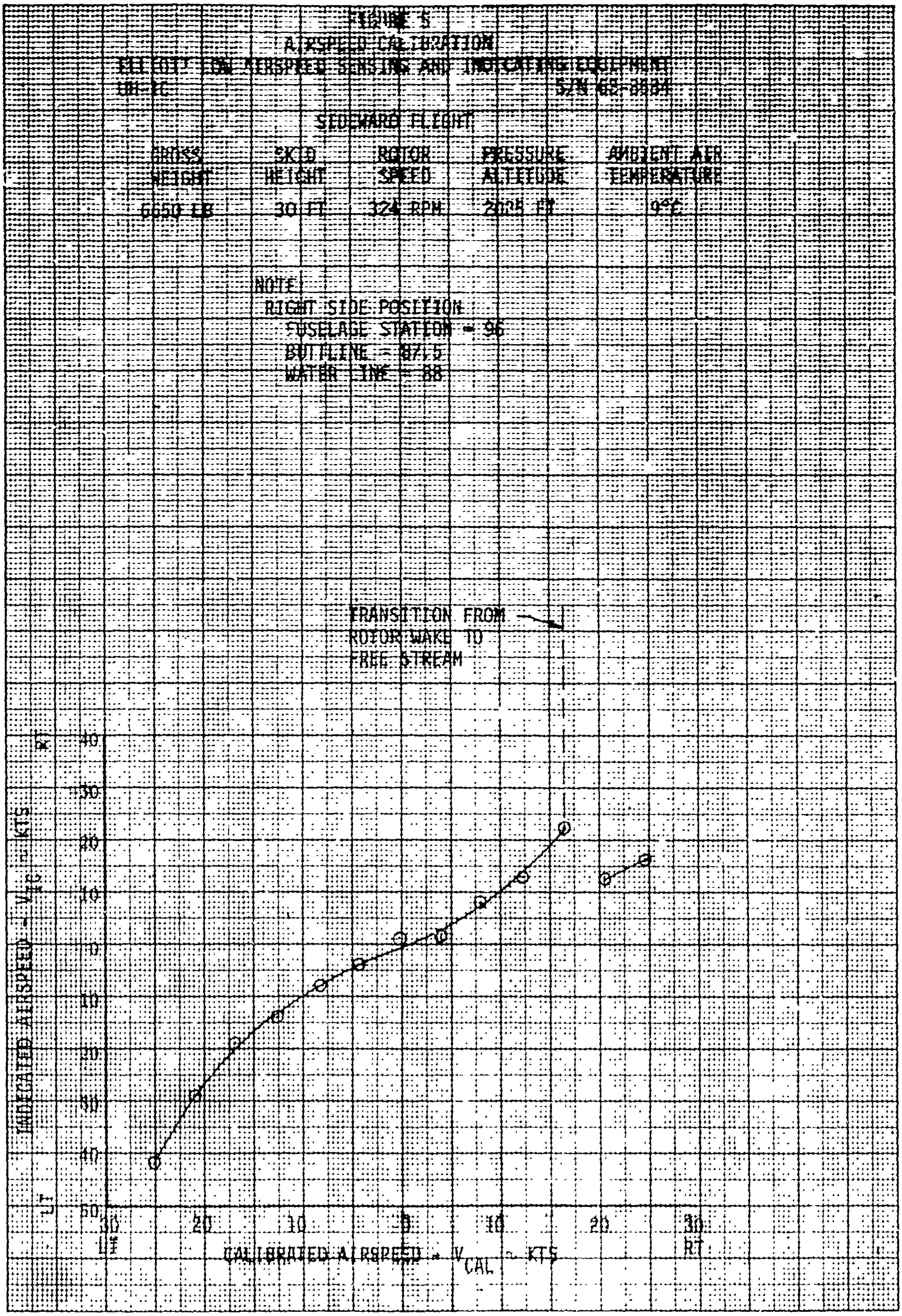


FIGURE 5
AIRSPEED CALIBRATION
ELLIOTT LOW AIRSPEED SENSING AND INDICATING EQUIPMENT
UH-1C
SIDEWARD FLIGHT
GROSS WEIGHT
SKID HEIGHT
ROTOR SPEED
PRESSURE ALTITUDE
AMBIENT AIR TEMPERATURE
6650 LB
30 FT
324 RPM
2025 FT
9°C
NOTE:
RIGHT SIDE POSITION
FUSELAGE STATION = 96
BUTTLINE = 87.5
WATER LINE = 88
TRANSITION FROM ROTOR WAKE TO FREE STREAM
INDICATED AIRSPEED - V_IC - KTS
RT
LT
40
30
20
10
0
10
20
30
40
50
30
20
10
0
10
20
30
LT
RT
CALIBRATED AIRSPEED - V_CAL - KTS

FIGURE 6

AIRSPEED CALIBRATION

ELLIOTT LOW AIRSPEED SENSING AND INDICATING EQUIPMENT

UH-1C S/N 63-8684

SIDEWARD FLIGHT

GROSS WEIGHT	SKID HEIGHT	ROTOR SPEED	PRESSURE ALTITUDE	AMBIENT AIR TEMPERATURE
6650 LB	30 FT	324 RPM	2025 FT	9°C

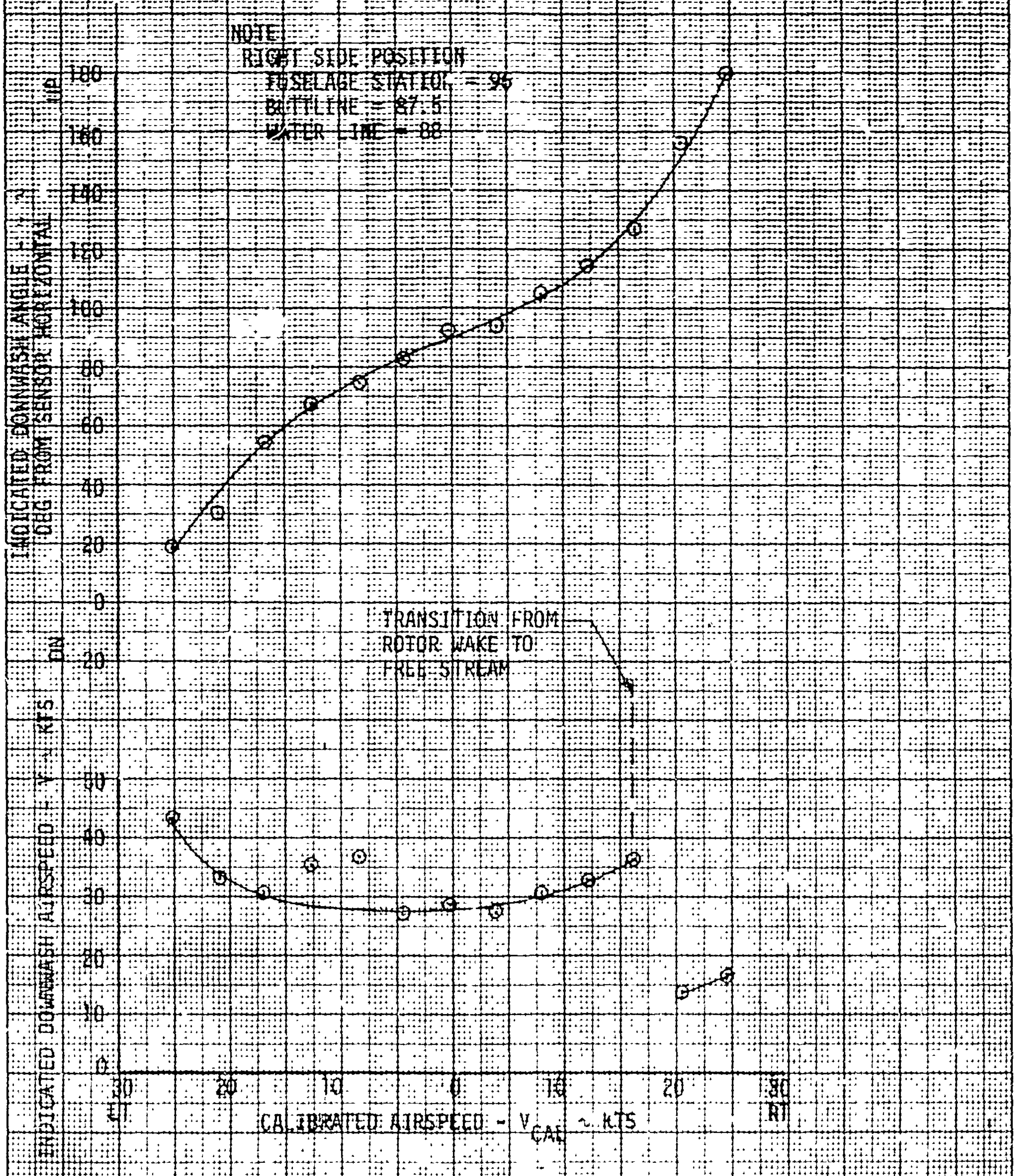
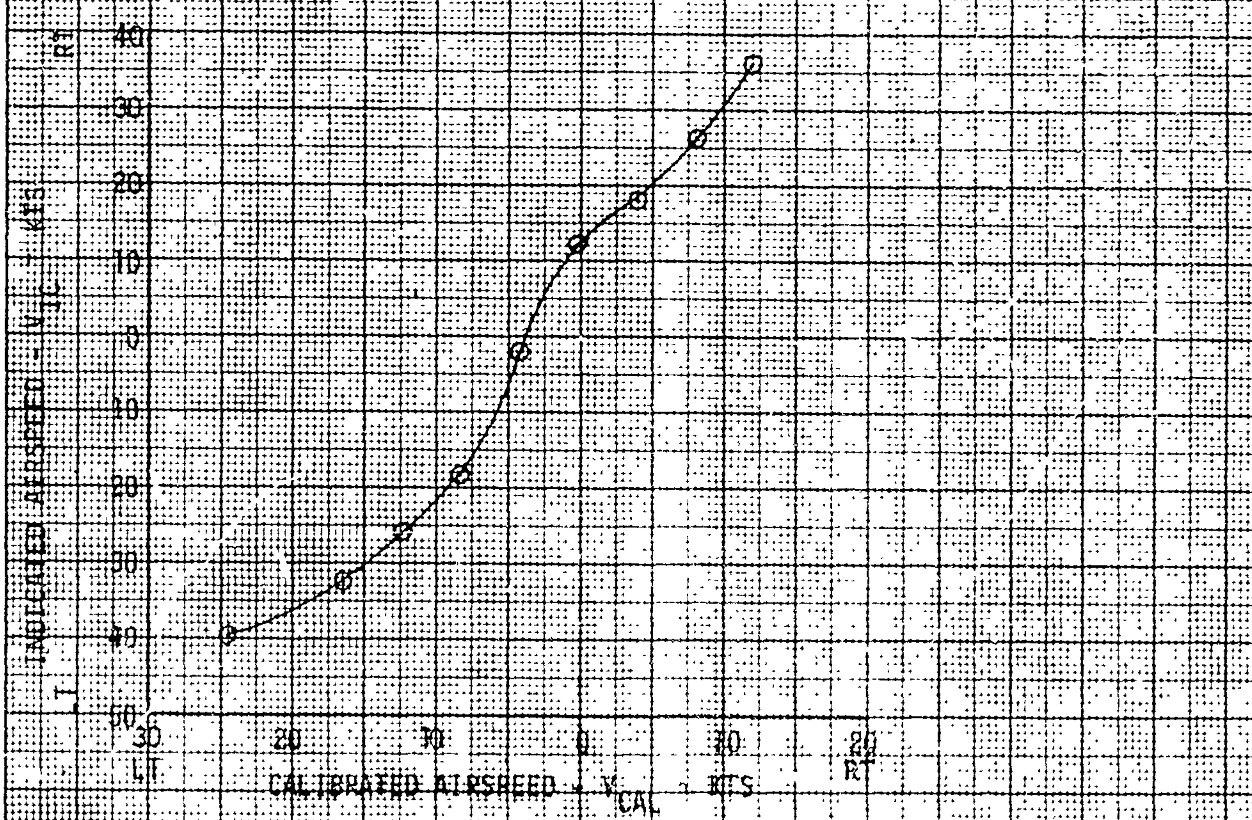


FIGURE 7
AIRSPEED CALIBRATION
SELECT? FOR AIRSPEED SENSING AND INDICATING EQUIPMENT
UH-1C S/N 63-8624

SIDEWARD FLIGHT

GROSS WEIGHT	SKID HEIGHT	ROTOR SPEED	PRESSURE ALTITUDE	AMBIENT AIR TEMPERATURE
8500 LB	30 FT	324 RPM	2100 FT	11°C

NOTE:
CENTER CABIN POSITION
FUSELAGE STATION = 30.5
BUTTLINE = -9.5
WATER LINE = 86



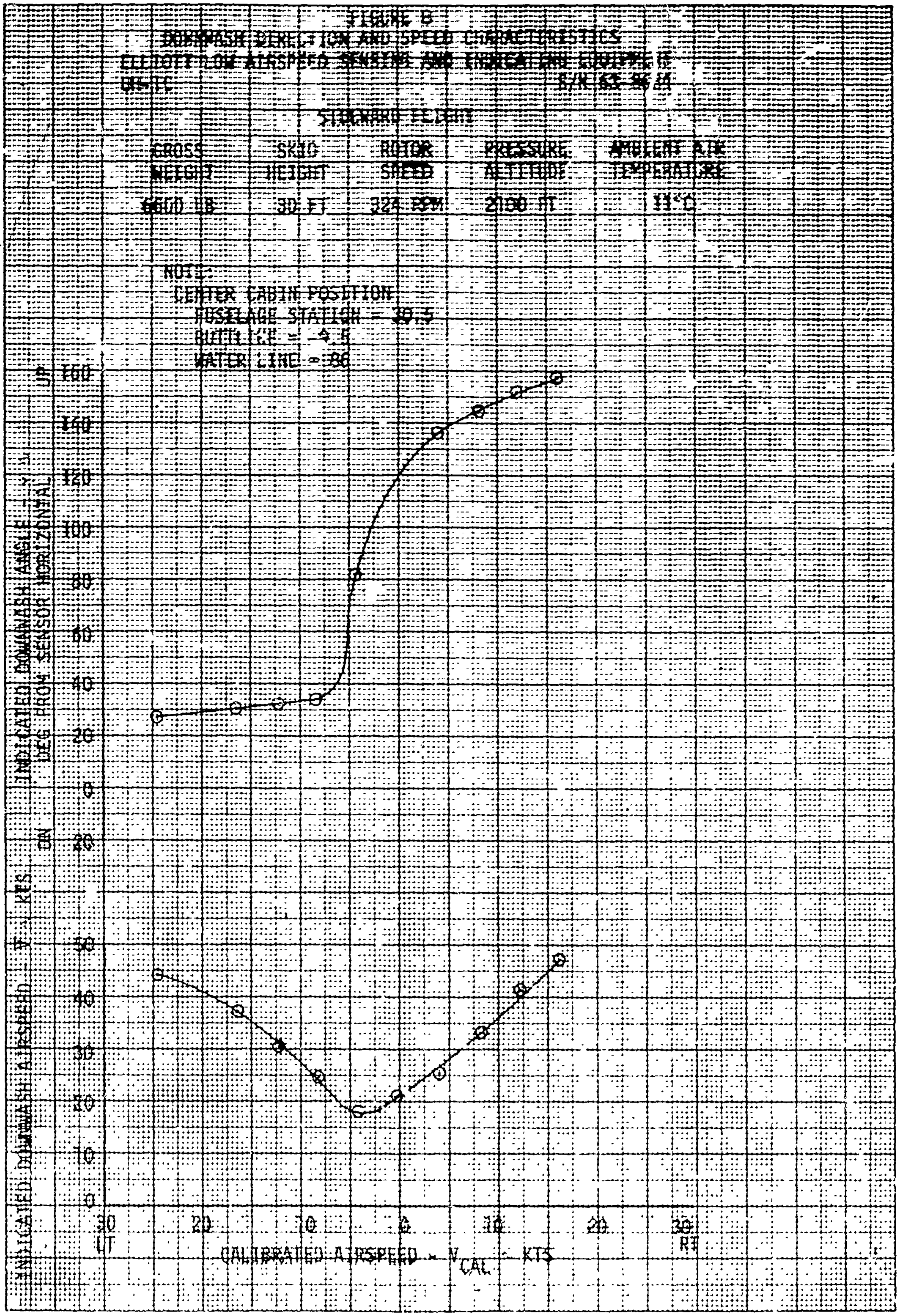


FIGURE 8
DOWNWASH DIRECTION AND SPEED CHARACTERISTICS
ELLIOTT LOW AIRSPEED SENSING AND INDICATING EQUIPMENT
UH-1C
SIDEWARD FLIGHT
GROSS WEIGHT
SKID HEIGHT
ROTOR SPEED
PRESSURE ALTITUDE
AMBIENT AIR TEMPERATURE
6600 LB
30 FT
324 RPM
2130 FT
NOTE:
CENTER CABIN POSITION
FUSELAGE STATION
WATER LINE
INDICATED DOWNWASH ANGLE
DEG FROM SENSOR HORIZONTAL
UP
DN
INDICATED DOWNWASH AIRSPEED
KTS
160
140
120
100
80
60
40
20
0
20
50
40
30
20
10
0
30
20
10
0
10
20
30
LT
RT
CALIBRATED AIRSPEED ~ V_{CAL} ~ KTS

FIGURE 9
AIRSPEED SYSTEM PERFORMANCE CHARACTERISTICS IN SIDESLIP
ELLIOTT LOW AIRSPEED SENSING AND INDICATING EQUIPMENT
UH-1C S/N 63-8624

FORWARD FLIGHT

GROSS WEIGHT	TRIM AIRSPEED	ROTOR SPEED	PRESSURE ALTITUDE	AMBIENT AIR TEMPERATURE
6300 LB	60 KCAS	324 RPM	3000 FT	24°C

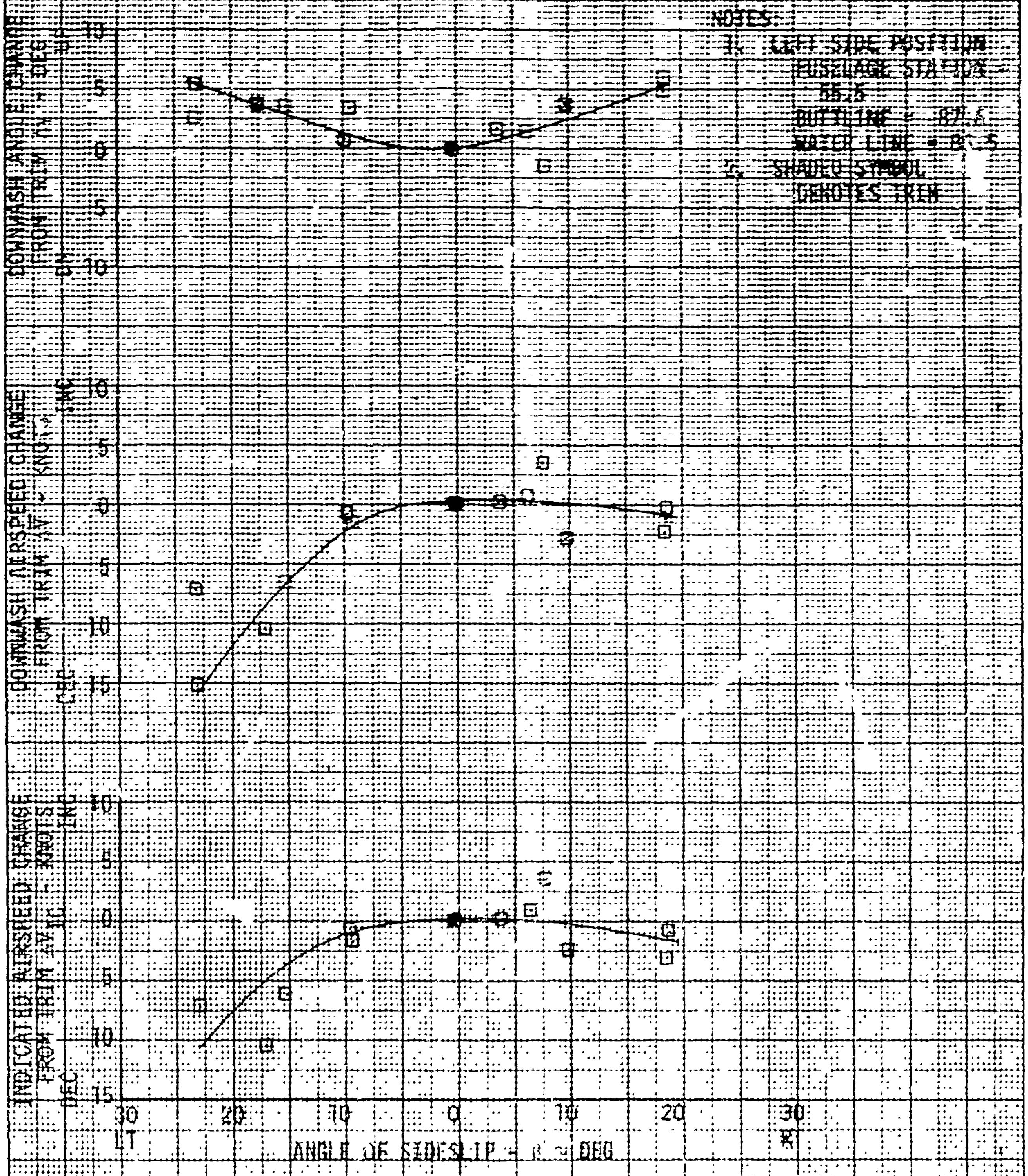


FIGURE 10

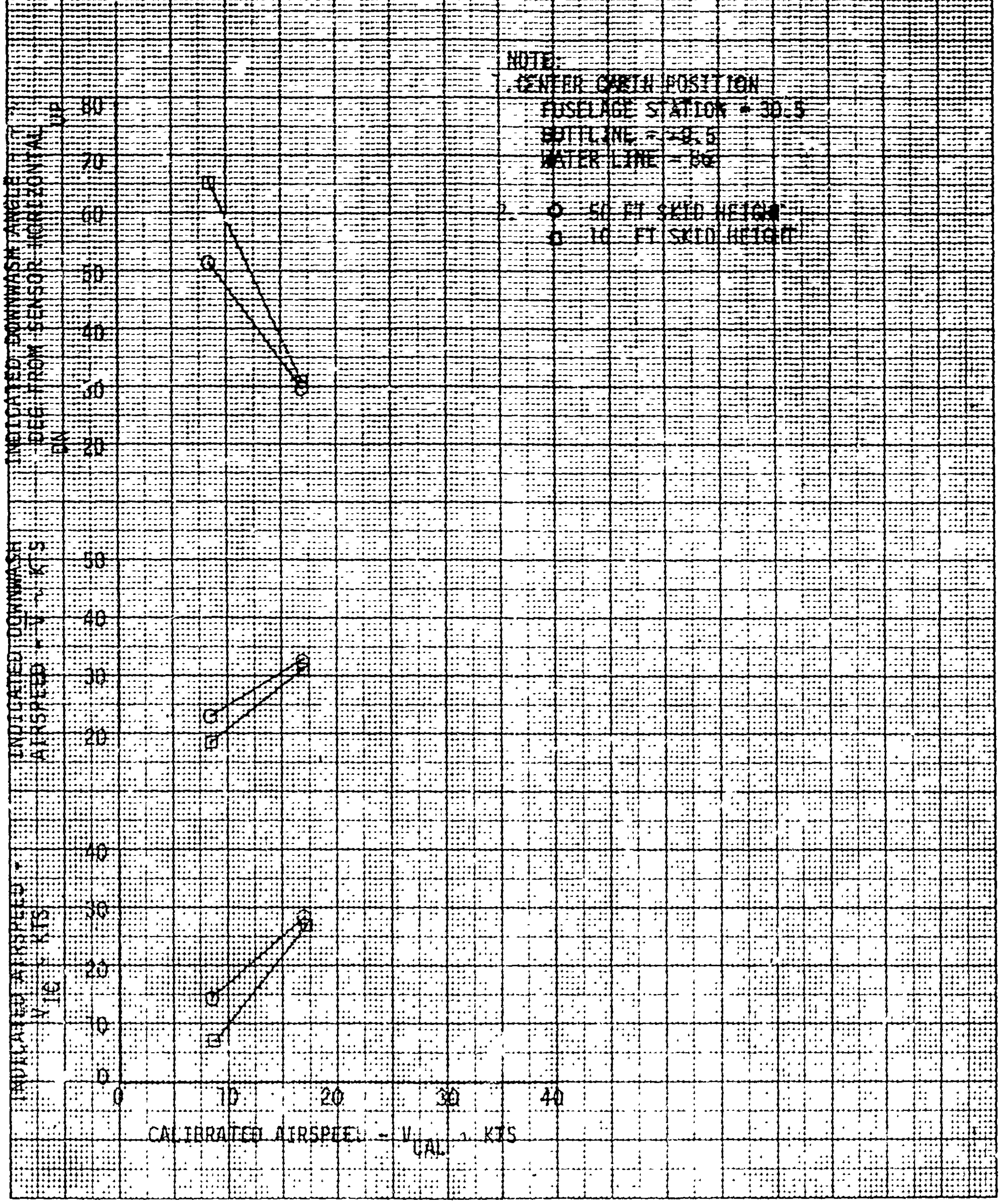
GROUND PROXIMITY EFFECTS ON AIRSPEED SYSTEM PERFORMANCE

ELLIOTT LOW AIRSPEED SENSING AND INDICATING EQUIPMENT

UH-1C S/N 63-8684

FORWARD FLIGHT

GROSS WEIGHT	ROTOR SPEED	PRESSURE ALTITUDE	AMBIENT AIR TEMPERATURE
6450 LB	324 RPM	2050 FT	25°C



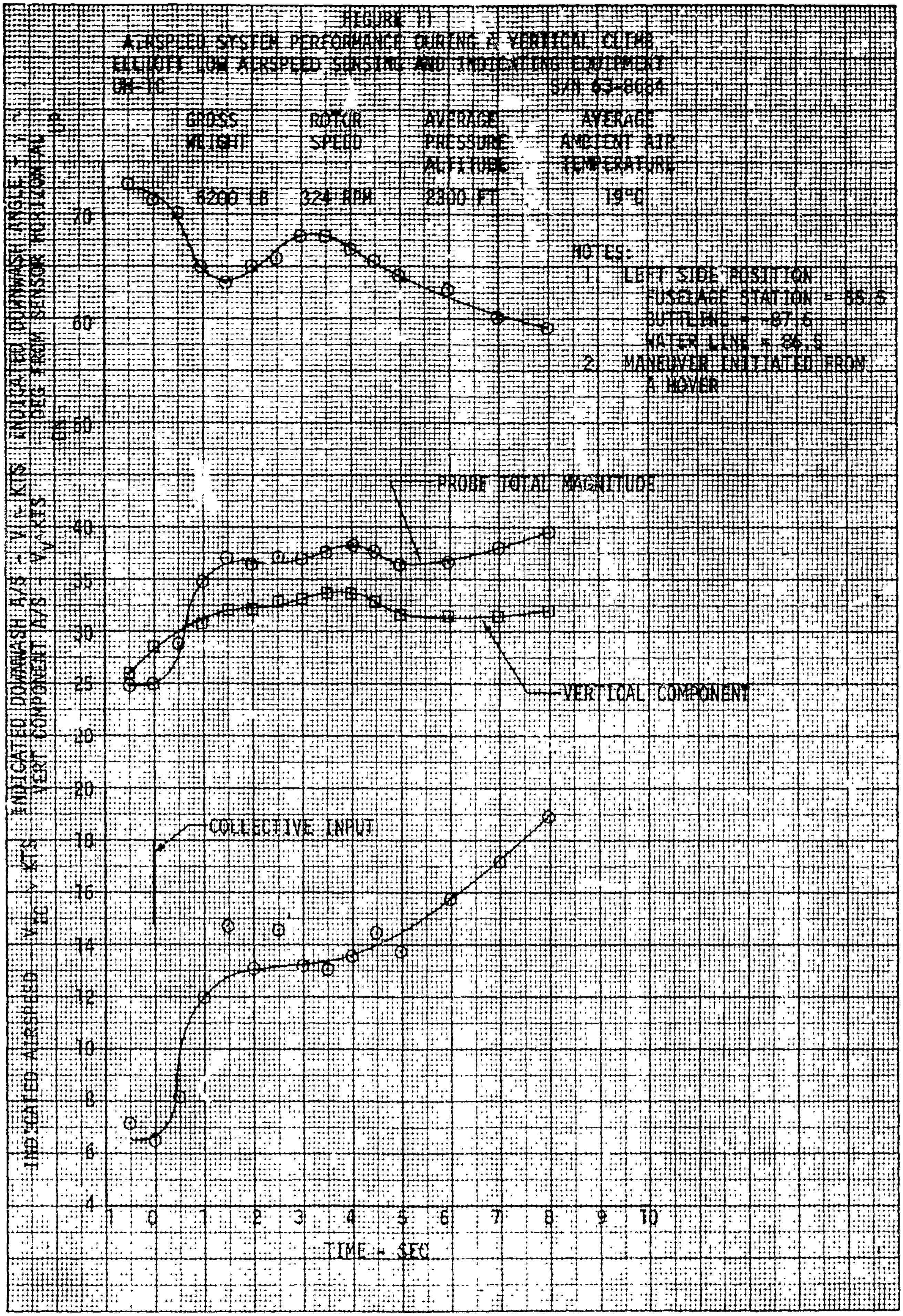


FIGURE 11
AIRSPEED SYSTEM PERFORMANCE DURING A VERTICAL CLIMB
ELLIOTT LOW AIRSPEED SENSING AND INDICATING EQUIPMENT
UH-1C
S/N 63-8684
GROSS WEIGHT
ROTOR SPEED
AVERAGE PRESSURE ALTITUDE
AVERAGE AMBIENT AIR TEMPERATURE
8200 LB
324 RPM
2300 FT
19°C
NOTES:
1. LEFT SIDE POSITION
FUSELAGE STATION = 88.5
BUTTLINE = -87.6
WATER LINE = 36.5
2. MANEUVER INITIATED FROM A HOVER
PROBE TOTAL MAGNITUDE
VERTICAL COMPONENT
COLLECTIVE INPUT
INDICATED DOWNWASH ANGLE
DEG FROM SENSOR HORIZONTAL UP
INDICATED DOWNWASH A/S - KTS
VERT COMPONENT A/S - KTS
INDICATED AIRSPEED - KTS
TIME - SEC